application of the irritant. When the circulation is about to be resumed, the stagnating mass in the vessel appears to thaw as it were. The corpuscles are not pushed onwards in mass as a coherent plug; but the homogeneity of appearance is suddenly lost by the resumption of their normal form by the corpuscles and the reappearance of their differentiating outlines, which were previously obscured by their blending with one another and with the walls of the vessels. Before this takes place, the vessel very gradually assumes a lighter tint, passing in some instances from a deep red to a pale orange. This appears to be due to a washing away of extruded colouring-matter.

When this change from homogeneity to heterogeneity commences, although sufficiently progressive in its character as it traverses the vessel, it nevertheless takes place with considerable rapidity. It is evidently brought about by the gradual permeation of new liquor sanguinis among the corpuscles, and the contemporaneous abolition of their cohesive attraction for each other in accordance with the principles previously established.

II. "Researches on Turacine, an Animal Pigment containing Copper." By A. W. Church, M.A. Oxon., Professor of Chemistry in the Royal Agricultural College, Cirencester. Communicated by Dr. W. A. Miller, Treas. R.S. Received May 4, 1869.

(Abstract.)

From four species of *Touraco*, or Plantain-eater, the author has extracted a remarkable red pigment. It occurs in about fifteen of the primary and secondary pinion feathers of the birds in question, and may be extracted by a dilute alkaline solution, and reprecipitated without change by an acid. It is distinguished from all other natural pigments yet isolated, by the presence of 5·9 per cent. of copper, which cannot be removed without the destruction of the colouring-matter itself. The author proposes the name *turacine* for this pigment. The spectrum of turacine shows two black absorption-bands, similar to those of scarlet cruorine; turacine, however, differs from cruorine in many particulars. It exhibits great constancy of composition, even when derived from different genera and species of Plantain-eater; as, for example, the *Musophaga violacea*, the *Corythaix albo-cristata*, and the *C. porphyreolopha*.

III. "On the Radiation of Heat from the Moon." By the Earl of Rosse, F.R.S. Received May 27, 1869.

The following experiments on Lunar Radiant Heat were undertaken with the view of ascertaining whether with more powerful and more suitable means than those previously employed by others, with little or no success, it would be possible to detect and estimate the amount of heat which reaches the earth's surface from the moon.

Professor Piazzi Smyth had conducted a series of experiments on the Peak of Teneriffe with a thermopile, but apparently without any means of concentrating the moon's heat beyond the ordinary polished metal cone.

Melloni had employed a glass lens of considerable diameter (I believe about three feet); but as glass absorbs rays of low refrangibility, it was not so well adapted to concentrate heat as a metallic mirror.

In the following experiments the point sought to be determined was, in what proportions the moon's heat consists of

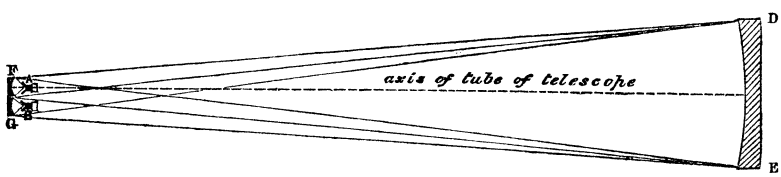
(1) That coming from the interior of the moon, which will not vary with the phase.

(2) That which falls from the sun on the moon's surface, and is at once reflected regularly and irregularly.

(3) That which, falling from the sun on the moon's surface, is absorbed, raises the temperature of the moon's surface, and is afterwards radiated as heat of low refrangibility.

The apparatus consisted of a thermopile of four elements, the faces half an inch square, on which all the moon's heat which falls on the large speculum of the 3-foot telescope is concentrated, by means of a concave mirror of $3\frac{1}{2}$ inches aperture, 2·8 inches focal length.

As it was found difficult to compensate the effects of unequal radiation on the anterior face of the pile, by exposing the posterior face also of the *same* pile to radiation from the sky, during the later experiments (beginning with March 23rd) two piles were used, and the following was the form of apparatus adopted.



D E is the large mirror of the telescope; F G the two small concave mirrors of $3\frac{1}{2}$ inches aperture, and 2·8 inches focal length, fixed in the plane of the image formed by the large mirror D E. The two thermopiles are placed respectively in the foci of F and G, their anterior faces shielded from wind and other disturbing causes by polished brass cones, and their posterior faces kept at a nearly uniform temperature by means of brass caps filled with water. The thermopiles and accompanying mirrors are supported by a bar screwed temporarily on the mouth of the tube. Two wires are connected with the two poles of each pile; and the ends of the wires are connected, two and two, close to the galvanometer, in such a manner that a given amount of heat on the anterior face of one pile will produce a deviation equal in amount, and opposite in direction, to that produced by an equal amount of heat on the anterior face of the other pile. Thomson's Reflecting Galvanometer was the one used.

This apparatus has not yet had a fair trial, as I was unable to obtain from Messrs. Elliot a pile ready made of similar dimensions to that which I already possessed. That which they sent had only one-fourth the required area of face.

The following is a summary of the results :—

Reference number.	Date of observation.	Mean error.	Mean deviation.	Deviation (calculated).	Observed deviation reduced to full moon.	180° − moon's distance from the sun.	Mean altitude of moon.	Number of readings.	
	1868.								
I.	Dec. 30.	...	103·7	94·1	110	19°			
II.	„ 31.	...	85·1	85·8	99·2	33			
	1869.								
III.	Jan. 1.	...	67·5	73·1	92·1	47			
IV.	„ 21.	...	34	41·9	81·1	79	...	...	Occasional clouds.
V.	„ 26.	...	83	96·7	85·8	15	56°		White frost. Mirrors became dewed; but the readings taken after this took place have been rejected.
VI.	Mar. 23.	34	57	67·7	84·2	57	...	40	Occasional clouds.
VII.	„ 27.	49	115	99·6	115	5	35	15	Occasional clouds, strong gusts of wind.
VIII.	„ 28.	35	113	96·1	117	16	30	49	No note of cloud, very little breeze, generally calm.
IX.	„ 31.	...	17	62·8	27·7	58	18	31	Moon low, sky covered with hazy clouds, through which the moon was seen with much diminished brilliancy.
X.	April 14.	...	......	8·3	......	123	...	4	Very clear and calm, but moon low; no perceptible impulse imparted to the needle.
XI.	„ 17.	27	13·1	16·6	79	110	27	65	Wind blowing strong into the mouth of the tube nearly the whole time.
XII.	„ 19.	43	35·5	36·3	96	85	25	14	No note of cloud till just at the end of these observations.
XIII.	„ 20.	85	33	48·8	68	72	35	51	A very little wind; occasional clouds.
XIV.	„ 22.	38	12·1	75·5	......	45	...	15	Halo with hazy clouds; moon seen through them with much-diminished brilliancy.
XV.	„ 24.	28	84	95·3	88·2	18	30	29	Frequent passing clouds during the latter part of these observations.
XVI.	„ 25.	45	88·4	99·4	88·8	6	25	66	No cloud visible, but haziness suspected, as it existed both at sunset and at sunrise.
1	2	3	4	5	6	7	8	9	

In column 3 is given the mean of the deviations of all the single differences from the mean difference of all the readings taken with the moon on and with the moon off the apparatus.

In column 4 the arithmetic mean of all the observed deviations.

In column 5 the calculated deviation for each night at midnight, on the assumption that the deviation corresponding to full moon $=100$, and that the moon is a smooth sphere. We have then

Q (quantity of heat coming from the moon's surface)

$$=C\int_{\epsilon-\frac{\pi}{2}}^{\frac{\pi}{2}}\cos\theta\,.\cos(\epsilon-\theta)\,d\theta$$

$$=\frac{C}{2}\{\overline{\pi-\epsilon}\,.\cos\epsilon+\sin\epsilon\}^{*},$$

where $\epsilon=\pi-$apparent distance between the centres of the sun and moon.

$$\text{When } \epsilon=0 \text{ (full moon), } Q=\frac{C}{2}\,.\,\pi,$$

$$\text{when } \epsilon=\frac{\pi}{2} \text{ (half moon), } Q=\frac{C}{2},$$

$$\text{when } \epsilon=\pi \text{ (new moon), } Q=0\,;$$

$\therefore$ if full moon $=100$, Q in general

$$=100\left(\overline{1-\frac{\epsilon}{\pi}}\cos\epsilon+\sin\epsilon\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad (a)$$

In column 6 we have the deviation for full moon calculated from the observed mean deviation for each night.

In column 7 the supplement of the apparent distance between the centres of the sun and moon.

In column 8 the approximate mean altitude of the moon.

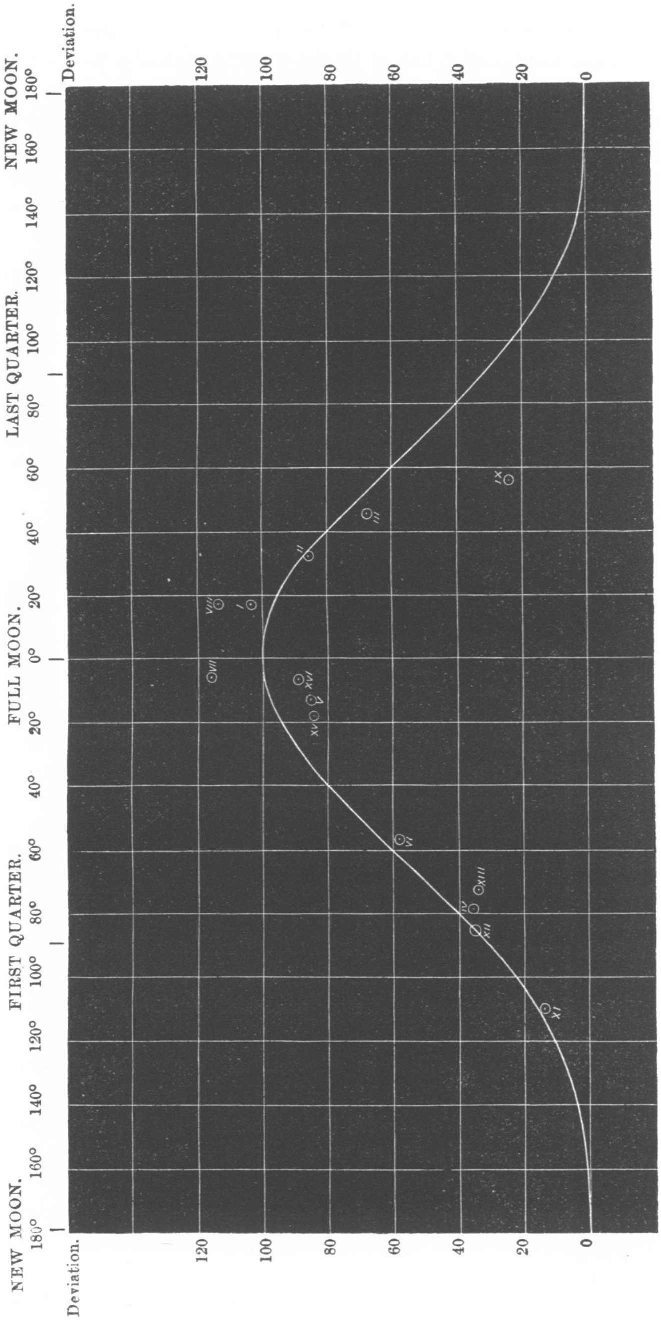
In column 9 the number of times the telescope was put on or off the moon during the observations included in the mean result.

In all these observations the deviations which have been measured are those due to the difference between the radiation from a circle of sky containing the moon's disk, and that from a similar circle of sky close to it not containing the moon's disk.

The annexed diagram will show approximately the rate at which the moon's light increases and diminishes with its phases as deduced from formula (a); and the ringed dots with the accompanying Roman figures (for reference) give the quantity of the moon's heat as determined by observation on different nights.

Although there is considerable discordance between some of the observed

* This formula is based on the assumption that the heat coming to the earth from an element (δS) of the moon's surface $=K\,.\,\delta S\,.\cos\theta\,.\cos\phi$, θ and ϕ being respectively the inclinations of the lines to the sun and to the earth from the normal to that point of the moon's surface, and K a constant.


NEW MOON.
LAST QUARTER.
FULL MOON.
FIRST QUARTER.
NEW MOON.
Deviation.
Deviation.

and calculated quantities of heat, the results suggest to us that the law of variation of the moon's heat will probably be found not to differ much from that of the moon's light. It therefore follows that not more than a small part of the moon's heat can come from the first of the three sources already mentioned.

With the view of ascertaining what proportion of the sun's heat does not leave the moon's surface until after it has been absorbed, some readings of the galvanometer were taken on four different nights near the time of full moon, with a disk of thin plate glass in front of the face of each pile; and the deviation was about six or eight divisions.

As the glass screens were examined with care for dew after removal on each night, and none was perceived except on one occasion, the probable percentage of the *moon's* heat which passes through plate glass is 8, or rather less.

Few experiments appear to have been made on the absorptive power of glass for the *sun's* rays; but, from the best data that I have been able to obtain, I find that probably about 80 per cent. pass through glass.

The greater part of the moon's heat which reaches the earth appears, therefore, to have been first absorbed by the lunar surface.

It now appeared desirable to verify this result, as far as possible, by determining by direct experiment the proportion which exists between the heat which reaches the earth from the sun and from the moon.

If we start with the assumption that the sun's heat is composed of two portions,

the luminous rays, whose amount $=\mathrm{L}$,

and

the non-luminous, ,, ,, $=\mathrm{O}$,

also that the moon's light consists of two corresponding portions, L′, O′, the luminous not being absorbed, and the non-luminous being entirely absorbed in their passage through glass, then

$$\left.\begin{aligned}\frac{\mathrm{L}}{\mathrm{L+O}}&=\cdot 8,\\ \frac{\mathrm{L}'}{\mathrm{L}'+\mathrm{O}'}&=\cdot 08;\end{aligned}\right\}\quad \therefore\ \frac{\mathrm{L}}{\mathrm{L}'}\times\frac{\mathrm{L}'+\mathrm{O}'}{\mathrm{L+O}}=10.$$

Substituting for $\frac{\mathrm{L}}{\mathrm{L}'}$ its generally received value (800,000), we have

$$\frac{\mathrm{L}'+\mathrm{O}'}{\mathrm{L+O}}=\frac{1}{80,000}. \qquad (b)$$

Owing to the extremely uncertain state of the weather, only one series of eighteen readings was obtained for the determination of the sun's heat. A beam of sunlight was thrown, by means of a plane mirror, alternately on and off a plate of polished metal with a hole ·175 inch in diameter. At a short distance behind this the pile was placed. The deviation thus found was

connected with that previously found for Full Moon by using the deviation produced by a vessel of hot water as a term of comparison.

The relative amount of solar and lunar radiation thus found was

$$89819:1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (c)$$

which is quite as near that given by (b) as we could expect when we consider the roughness of the data.

As a further confirmation of the correctness of the two rough approximations to the value of the ratio existing between the sun's and the moon's radiant heat already given, the subject was investigated from a purely theoretical point of view. It was assumed

(1) That the quantity of heat leaving the moon at any instant may without much error be considered the same as that falling on it at that instant.

(2) That the absorptive power of our atmosphere is the same for lunar and solar heat.

(3) That, as was already assumed in obtaining formula (a), the moon is a *smooth* sphere not capable of reflecting light *regularly*. Then the heat which leaves the moon in all directions = quantity which falls on the moon $=\frac{1}{13\cdot55}$ of the quantity which falls on the earth from the sun

$$=\mathrm{K}\,.\int_0^{\pi}\{(\pi-\epsilon)\,.\cos\epsilon+\sin\epsilon\}\sin\epsilon\,.\,d\epsilon=\frac{\mathrm{K}}{4}\,3\pi.$$

The part which falls on the earth

$$=\mathrm{K}\,.\int_0^{\frac{1}{59\cdot964}}\{(\pi-\epsilon)\cos\epsilon+\sin\epsilon\}\sin\epsilon\,.\,d\epsilon$$

$$=\frac{\mathrm{K}}{4}\times\left\{-\pi\,.\text{ versin }(1^\circ\ 55')+\frac{2+\cos(1^\circ\ 55')}{59\cdot964}-\tfrac{3}{2}\sin(1^\circ 55')\right\}$$

$$=\frac{\mathrm{K}}{4}\,.\,\mathrm{E}\text{ suppose;}$$

therefore (if we may be allowed the expression)

$$\frac{\text{sun-heat}}{\text{moon-heat}}=\frac{13\cdot55\times3\pi}{\mathrm{E}}$$

$$=\frac{79{,}000}{1}\text{ (quam proximè)}. \quad . \quad . \quad . \quad (d)$$

In the above, the proportion between the areas of surface presented by the moon and earth to the sun is taken $=13\cdot55$, and the angle subtended by the earth at the moon $=1^\circ\ 55'$.

The value of the readings of the galvanometer was determined by comparison with those obtained by using a vessel of hot water coated with shellac and lampblack varnish as a source of heat. The vessel was of tin, circular, and subtended the same angle at the small concave reflectors as the large mirror of the telescope. It was thus found that (the radiating power of the moon being supposed equal to that of the lampblack surface and the earth's atmosphere not to influence the result) a deviation of 90 for full

moon appears to indicate an elevation of temperature through 500° Fahr.* In deducing this result allowance has been made for the *imperfect* absorption of the sun's rays by the lunar surface.

In the present imperfect state of these observations it would be premature to discuss them at greater length; but as some months must elapse before any more complete series can be obtained, and the present results are sufficient to show conclusively that the moon's heat is capable of being detected with certainty by the thermopile, I have thought it best to send this account to the Royal Society; and I shall be most happy to receive suggestions as to improvements in the method of working, and as to the direction in which it may be most desirable to carry on future experiments.

IV. "On a New Arrangement of Binocular Spectrum-Microscope." By William Crookes, F.R.S. &c. Received April 23, 1869.

The spectrum-microscope, as usually made, possesses several disadvantages: it is only adapted for one eye†; the prisms having to be introduced over the eyepiece renders it necessary to remove the eye from the instrument, and alter the adjustment, before passing from the ordinary view of an object to that of its spectrum, and *vice versâ*; the field of view is limited, and the dispersion comparatively small.

I have devised, and for some time past have been working with, an instrument in which the above objections are obviated, although at the same time certain minor advantages possessed by the ordinary instrument, such as convenience of examining the light reflected from an object, and comparing its spectrum with a standard spectrum, are not so readily associated with the present form of arrangement.

The new spectrum-apparatus consists of two parts, which are readily attached to an ordinary single or binocular microscope; and when attached they can be thrown in or out of adjustment by a touch of the finger, and may readily be used in conjunction with the polariscope or dichrooscope; object-glasses of high or low power can be used, although the appearances are more striking with a power of $\frac{1}{2}$-inch focus or longer; and an object as small as a single corpuscle of blood can be examined and its spectrum observed.

* This may seem a very large rise of temperature; but it is quite in accordance with the views of Sir John Herschel on the subject (Outlines of Astronomy, section 432 and preceding sections), where he says that, in consequence of the long period of rotation of the moon on its axis, and still more the absence of an atmosphere, "The climate of the moon must be most extraordinary, the alternation being that of unmitigated and burning sunshine, fiercer than that of an equatoreal noon; and the keenest severity of frost, far exceeding that of our polar winters, for an equal time." And again, ". . . . the surface of the full moon exposed to us must necessarily be very much heated, possibly to a degree much exceeding that of boiling water."

† Mr. Sorby in several of his papers (Proc. Roy. Soc. 1867, xv. p. 433; 'How to Work with the Microscope,' by L. Beale, F.R.S., 4th edition, p. 219) refers to a binocular spectrum-microscope; but he gives no description of it, and in one part says that it is not suited for the examination of any substance less than $\frac{1}{10}$ of an inch in diameter.